

DERWENT-ACC-NO: 2003-523508
DERWENT-WEEK: 200624
COPYRIGHT 2008 DERWENT INFORMATION LTD

TITLE: Fan blade for industrial fan used in erosive conditions, such as in peat-fired or coal-fired power plants, has steel leading edge comprising leading part, filler wire, and back plate

INVENTOR: HUIKO A ; KEMPPAINEN M

PATENT-ASSIGNEE:

| ASSIGNEE | CODE |
|------------|------|
| FORTUM OYJ | NES0 |

PRIORITY-DATA: 2001W0-FI01111 (December 17, 2001)

PATENT-FAMILY:

| PUB-NO | PUB-DATE | LANGUAGE |
|--------------------|-----------------|----------|
| <u>W0 03051559</u> | June 26, 2003 | EN |
| <u>A1</u> | | |
| <u>AU</u> | June 30, 2003 | EN |
| <u>2002219257</u> | | |
| <u>A1</u> | | |
| <u>FI</u> | August 11, 2004 | FI |
| <u>200400845 A</u> | | |
| <u>FI 116890</u> | March 31, 2006 | FI |
| <u>B1</u> | | |

DESIGNATED-STATES: AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CO CR CU CZ DE DK DM DZ EC EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PH PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW AT BE CH CY DE DK EA ES FI FR GB GH GM GR IE IT KE LS LU MC MW MZ NL OA PT SD SE SL SZ TR TZ UG ZM ZW

APPLICATION-DATA:

| PUB-NO | APPL-DATE | APPL-NO | DESCRIPTOR |
|----------------|-------------------|----------------|------------|
| W02003051559A1 | December 17, 2001 | 2001W0-FI01111 | |
| AU2002219257A1 | December 17, 2001 | 2001W0-FI01111 | |
| FI 200400845A | December 17, 2001 | 2001W0-FI01111 | |
| FI 116890B1 | December 17, 2001 | 2001W0-FI01111 | |
| AU2002219257A1 | December 17, 2001 | 2002AU-219257 | |
| FI 200400845A | June 17, 2004 | 2004FI-000845 | |
| FI 116890B1 | June 17, 2004 | 2004FI-000845 | Based on |

INT-CL-CURRENT:

| TYPE | IPC | DATE |
|-------------------------|-----|----------|
| CIPS <u>B22 D 19/00</u> | | 20060101 |
| CIPP <u>B22 D 19/04</u> | | 20060101 |
| CIPS <u>F04 D 29/02</u> | | 20060101 |
| CIPS <u>F04 D 29/26</u> | | 20060101 |
| CIPS <u>F04 D 29/38</u> | | 20060101 |

ABSTRACTED-PUB-NO: WO 03051559 A1
BASIC-ABSTRACT:

NOVELTY - A fan blade includes: a blade section made by casting from metal-matrix composite material; steel leading edge bonded to the blade section by integral casting; and fixing elements for attaching the blade to a blade wheel hub of a fan. The leading edge has a leading part, filler wire in the bottom of the leading part, and back plate attached to leading edge and extending towards the blade section.

DESCRIPTION - A fan blade (2) includes a blade section made by casting from metal-matrix composite material containing reinforcing particles; a steel leading edge (1) bonded to the blade section by integral casting; and fixing elements (3) at one end of the blade section for attaching the blade to a blade wheel hub of a fan. The leading edge has a leading part (6) having a U-shape cross-section, filler wire (7) in the bottom of the leading part, and back plate (5) attached under the convex leg of the leading edge and extending on the whole length of the blade towards the blade section. The legs of U-shape form a convex part and concave part of the edge of the blade

An INDEPENDENT CLAIM is also included for producing the above fan blade by placing a steel leading edge within a mold, and filling the mold with a metal matrix composite material containing reinforcing particles, such that the leading edge within the mold is heated at least before filling the mold.

USE - For industrial fan used in erosive conditions, such as in peat- or coal-fired power plants.

ADVANTAGE - The invented fan blade is light weight, has high wear resistance, tolerance to elevated temperatures and certain degree of corrosion resistance, preferably has improved erosion resistance at temperatures of approximately 200 degrees C. It has high quality combined with an advantageous production cost. The balancing of the blower and the mounting of the blades is easier since the variation of the weight of the blades is small about less than 3% of the total weight of the blade.

DESCRIPTION OF DRAWING(S) - The figure is a schematic view of the blower blade.

Steel leading edge (1)

Fan blade (2)

Fixing elements (3)

Back plate (5)

Leading part (6)

Filler wire (7)

Tongues (10)

ABSTRACTED-PUB-NO: W0 03051559 A1
EQUIVALENT-ABSTRACTS:

MECHANICAL ENGINEERING

Preferred Component: The parts of the leading part are welded together. Part of the back plate inside the leading part comprises a row of triangular tongues (10) pointing towards the blade section. The leading part is heated using an electric resistor within the mold, or through electric induction.

Preferred Property: The weight variation of the blades of the same size and construction is 3%, preferably 1% at highest.

Preferred Method: The leading edge is heated to 70-200 degrees C, preferably 130 degrees C for at least 5 hours, before filling.

METALLURGY

Preferred Material: The metal-matrix composite material of the blade comprises aluminum, alloying components, and reinforcing filler consisting of silicon carbide, aluminum oxide, or other ceramic particles.

CHOSEN-DRAWING: Dwg.1/2

TITLE-TERMS: FAN BLADE INDUSTRIAL EROSION CONDITION PEAT FIRE COAL POWER PLANT
STEEL LEADING EDGE COMPRISE PART FILL WIRE BACK PLATE

DERWENT-CLASS: L02 M22 P53 Q56 X11

CPI-CODES: L02-J01B; M22-G03K1B; M22-H03F1;

EPI-CODES: X11-A09;

SECONDARY-ACC-NO:

CPI Secondary Accession Numbers: 2003-140966

Non-CPI Secondary Accession Numbers: 2003-415349

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
26 June 2003 (26.06.2003)

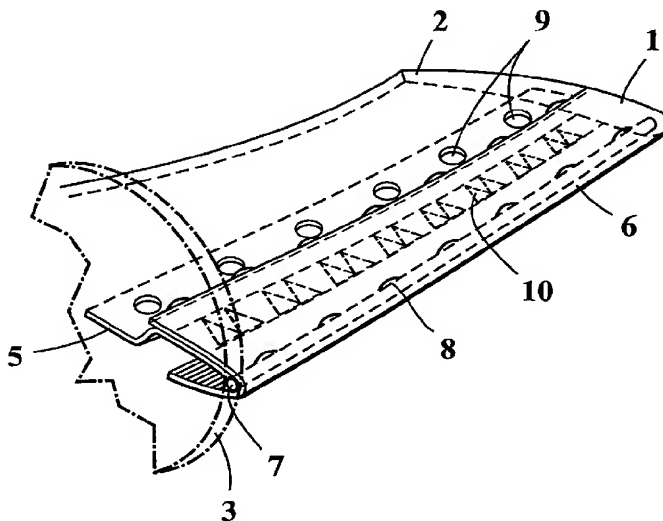
PCT

(10) International Publication Number
WO 03/051559 A1

- (51) International Patent Classification⁷: **B22D 19/00**, (74) Agent: **SEPPO LAINE OY**; Itämerenkatu 3 B, 19/14 // F04D 29/26
(21) International Application Number: PCT/FI01/01111 (81) Designated States (*national*): AE, AG, AL, AM, AT (utility model), AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ (utility model), CZ, DE (utility model), DE, DK (utility model), DK, DM, DZ, EC, EE (utility model), EE, ES, FI (utility model), FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK (utility model), SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.
(22) International Filing Date: 17 December 2001 (17.12.2001)
(25) Filing Language: English
(26) Publication Language: English
(71) Applicant (*for all designated States except US*): **FOR-TUM OYJ** [FI/FI]; Keilaniemi, FIN-02150 Espoo (FI).
(72) Inventors; and
(75) Inventors/Applicants (*for US only*): **KEMPPAINEN, Markku** [FI/TI]; Merenneidontie 24 D, FIN-02320 Espoo (FI). **HUISKO, Arvo** [FI/FI]; Mustajärventie 480, FIN-16300 Orimattila (FI).
(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: FAN BLADE AND METHOD FOR PRODUCING THE SAME



(57) Abstract: The present invention relates to a fan blade intended for use under erosive conditions and characterized by a light weight and high tolerance to erosion even at elevated temperatures up to approx. 220 °C. The invention is based on fabricating the blade (2) by casting from an aluminium-matrix composite alloy material filled with reinforcing particles. A steel wear pad (1) serving to further improve the wear resistance, strength and stiffness of the blade is bonded by integral casting to the leading edge of the blade (2). The innovation to manufacture the blade by using electrical heating for the steel wear pad and the mould enable to cast products free of defects, homogenous and equal of weights.

WO 03/051559 A1

WO 03/051559 A1



Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Fan blade and method for producing the same

The invention relates to a fan blade according to the preamble of claim 1 for use under erosive conditions, said blade being characterized by light weight and improved erosion resistance also at elevated temperatures up to approx. 220 °C. The invention also relates to a method for producing the fan blade.

Fan blades of the type concerned in the present invention are used in industrial fans operating under heavily erosive conditions either at ambient temperature or in atmospheres of elevated temperatures. Flue gas fans of peat- or coal-fired power plants represent a typical application. The flue gases exit the power plant boiler at a temperature of 120 °C to 150 °C with a high content of flyash, whose particulate matter is both erosive and corrosive. Other demanding applications comprise dryer fans in paper machines, ventilation blowers in mines, vacuum cleaning system blowers for dusty industrial processes and air-conditioning blowers for industrial buildings.

Fans are often used under conditions which are strongly erosive to the structures of the fans, whereby the fan blades must be changed as often as several times a year due to erosion or other damage. Such fan blade replacement entails extra costs caused by both the replacement operations themselves and the necessary shutdown times. These costs may rise to a substantial level. Particularly high costs may be incurred in power plants. In United States, the annual costs attributed to damage caused by erosion to the fans of coal-fired power plants have been estimated at USD 12 million (M. Menguturk & E.F. Sverdrup, Fan Erosion Control. Forschung im Ingenieurwesen 52(1986)1, pp. 9-12.

Due to the high rotational speeds involved, the structures of the fans are designed for minimum weight. Hence, the lightest possible materials such as alloys of aluminium are favored in the fan constructions. Due to their
5 low specific weight vs. strength, also different kinds of polymers are attractive, but the low erosion resistance and poor strength at elevated temperatures limit their use under erosive conditions and elevated temperatures. Also the erosion resistance of aluminum alloys as well as
10 their strength at elevated temperatures remain less than desirable. Moreover, the fatigue resistance and stiffness properties of aluminium alloys are relatively low. Therefore, steel is frequently used as a fan construction material in applications subject to erosion and elevated
15 temperatures. However, steel is hampered by its high density. Fans made from steel components are massive requiring heavy-duty bearings and support structures.

Exemplifying the function and service life of aluminium alloy fan blades, reference is made to a peat-fired power plant in Joensuu, Finland, previously owned by Fortum Power and Heat Oy. The flue gas fans (axial-type fans) of the power plant have blade rotors with a diameter of approx. 2000 mm and their speed of rotation
20 is from 1000 to 1500 rpm. Due to the large dimensions and high speed of rotation, the fan components must have a low mass, and therefore, their blades are made by casting and forging from a special lightweight aluminium alloy (containing 2-3 % Zn, 1-1.5 % Mg, trace amounts of Ti,
25 Cu, Si, Cr and Fe, the remainder being Al). Rotating at a high speed, the fan blades are bombarded by flyash particles carried along with the flue gas. The fan blade comprises the blade section proper and a stem keyed for mounting on the blade wheel hub, whereby for improved
30 wear resistance a hard-chromium plated lining strip of austenitic stainless steel is flush-mounted and fixed with screws in a recess, which is made to the leading
35

edges of the blade section. The hard-chromium plating on the protective wear strip has a thickness of 0.5 mm.

5 In this specific application, erosion caused by flyash particulate matter is so severe that the blades must be replaced once or twice a year. During these operating intervals, both the edge lining strip and the blade proper are worn into a condition beyond duty and repair. The trailing edge of the blade proper is worn totally
10 through at the end of the service cycle and the hard-chromium plated surface of the lining strip is eroded down to deep net-like cracking pattern. In addition to erosive wear, the rotor blades may suffer a sudden damage by breaking off at the area where the blade section joins
15 with the blade stem key. To improve their erosion resistance, thermal spray coating like HVOF -coating of the blades by aluminium oxide, tungsten carbide or chromium carbide has been attempted. However, such spray-coatings have not given an improved erosion tolerance to the
20 blades. Despite their limited service life, however, such blades find continuous use in the absence of more favourable alternatives.

25 The strength of metal alloys can be improved by complementing their base metal matrix with reinforcing filler materials. Such reinforcing fillers conventionally comprise ceramic materials that retain their solid-state composition at the casting temperature of the base metal, whereby the group of typical filler materials includes
30 silicon carbide, aluminium oxide, boron carbide and carbon in different forms and shapes. Also glass and steel are used to some extent. The base metal matrix thus reinforced generally is a light metal alloy such as the alloys of Al, Mg and Ti. While the most commonly used
35 metal-matrix particulate composite is an aluminium alloy filled with silicon carbide or aluminium oxide particles whose volume in the casting melt is 5 - 30 vol.-% with a

particle size of 5 - 40 μm , obviously other material combinations can be used.

5 Filler reinforced metals or metal alloys can be made into objects in a plurality of different ways, the most common production methods being casting and various pulverized metal processing methods. While casting is the production method of best cost-efficiency, casting a reinforced material is much more complicated than that of nonfilled
10 metal alloys. Typically, ceramic particles are used as the reinforcing filler material in castings, but fibers and pulverized material may in special cases be used as dispersed filler. The reinforcing filler particles must be dispersed homogeneously or in a desired manner in the
15 object being manufactured, and between the matrix metal and the filler material must be formed a strong bond free from brittle phases such as compounds or oxides of the matrix metal. To obtain such a strong bond between the filler particles and the matrix metal, the filler
20 particles must be coated or heat-treated. The bonding strength between these two can be improved during casting by applying an external pressure, which obviously complicates the design of the manufacturing process and leads into clumsy casting arrangements.

25 In the publication WO 96/38247 it is described a fan blade made of aluminium composite material by casting. The blade comprises a wear strip made of strip metal and cast integrally into the blade proper. The wear strip of
30 the fan blade is fabricated by bending a curved section conformant to the shape of the blade leading edge...To the inside of the curved section is attached by welding a drilled bonding plate which ensures a integral bond during casting and serves as a backing rail during
35 resurfacing welding of the wear strip. The problem with this structure is that the inner volume of the strip is limited by the edges of the strip and the bonding blade

so that the cast composite material that flows very
difficultly may not fill the volume within the edges of
the strip totally. On the other hand the strip is colder
than the cast material whereby the material may solidify
5 within the wear strip too fast and prevent the flow of
the cast material. These reasons lead to pores in the
blade within the wear strip.

Even though the pores may not essentially decrease the
10 strength of the blade, the weight of the blade and the
position of the center of gravity of the blade does
change because of the pores. This leads to serious
balancing problems in fast rotating large diameter
blowers. According to the WO 96/38247 the wear strip is
15 heated with a blow torch in order to prevent above
mentioned problems, but because of the structure of the
wear strip and the cooling of the strip before casting
the weight difference caused by pores within the wear
strip between different blades is still too high. If
20 there is a weight difference between the blades they must
be placed on the blower so that the weights of different
blades balance each other or balancing weights must be
used. In either case the blades must be accurately
weighed and the mounting of the blades is difficult.
25 Because of balancing procedure of the blower the
replacement of the blades is difficult and possible
unbalance that is left causes vibration problems of the
structures leading to the need of further maintenance and
monitoring of the apparatuses.

30 It is an object of the present invention to achieve a fan
blade and a method for manufacturing the same made from a
metal-matrix particulate composite material, said blade
having a wear resistance under erosive and high-
35 temperature conditions that is essentially better than is
achievable by means of conventional designs and having a
very small weight variation readily after casting.

The goal of the invention is accomplished through producing the blade by casting from an aluminium alloy filled with reinforcing particles. The leading edge of the blade is made of steel and integrally bonded to the blade during casting, which gives the blade a still further improved wear resistance and a small weight variation. The steel leading edge is heated at least prior to casting with electric current after the mould is closed.

More specifically, the blade according to the invention is characterized by what is stated in the characterizing part of claim 1.

The method for manufacturing the blade is characterized by what is stated in the characterizing part of claim 6.

The invention offers significant benefits.

In conventional tests performed in a laboratory-controlled environment, it has been found that the addition of reinforcing ceramic filler particles in a metal alloy in general does not significantly improve the wear resistance of the object under erosive conditions. Unexpectedly, however, it has been found that fan blades operating under erosive conditions can be given an essentially elevated wear resistance through manufacturing the blades from a metal-matrix particulate composite material. Plausibly, a precondition for an improved wear resistance is that the angle of incidence of the erosive particulate matter hitting the blade must be properly arranged particularly in the area of the trailing edge of the blade and the blade surface itself. Besides the improved wear resistance, the blade according to the invention offers elevated operating temperature at approx. 220 EC max. continuous duty, which is essentially

higher than that of a forged aluminium alloy blade.

The steel plate construction in the leading edge of the fan blade gives the blade a good bending strength. The bonding of the plate construction to the blade edge by means of integral casting strengthens and stiffens both the leading edge of the fan blade and the joining area of the blade section with the blade stem key, which is socketed on the blade wheel hub. By contrast, a wear strip separately mounted to the blade edge by screws does not impart a greater strength to the blade structure. A blade according to the invention wherein the leading edge is integrally cast on the blade and protrudes within the blade stem key has a strength and stiffness better compared with forged aluminium blades and clearly superior compared with conventional cast aluminium blades. The leading edge protrudes also from the distal end of the blade so that the leading edge extends over the whole length of the blade. A backplate of the leading edge extends over almost half of the width of the blade. These features guarantee that the blade does not shatter totally if hit by any large objects accidentally entering the fan.

The leading edge may be readily resurfaced by welding, which under certain circumstances can be an important benefit. For instance, under the operating conditions of a peat-fired power plant, the leading edge is eroded faster than the blade section itself. The construction of the leading edge permits resurfacing welding of the wear strip, thus making it possible to recondition blades having intact blade sections but eroded leading edges for reuse. In the example case of a peat-fired power plant, such resurfacing welding may give the fan blades a service life better than three years. Moreover, the structural material of the blades can be recycled. The material may be melted and recast into a blade section in

the same fashion as aluminum alloys are recycled. Thus, the material is fully recyclable.

5 The blades according to the present invention have a high quality combined with an advantageous production cost. The steel leading edge provides a possibility to manufacture blades that have a minimum form and weight variation. The blades are further ground by a diamond grinder in order to further minimize the weight variation and to give the blade a smooth surface. Smoothing the
10 surface improves further the abrasion resistance by removing protrusions and dents from the blade. If a abrading particles hit such a dent or protrusion, they start to wear a groove over the blade. Grooving of the
15 blade may cause imbalance or disturbance of the flow and force to fix or change the blade.

The greatest advantage of the invention is that the balancing of the blower and mounting of the blades is
20 easier since the variation of the weight of the blades is small, normally less than 3% of the total weight of a blade of a certain size. Also the tolerances of the blade can be tighter whereby the performance of the single blade does not vary, whereby the operating balance of the
25 blower is further improved. As is well known the static and dynamic balance has great effect on the durability and operational life of machinery. The mounting of the blades becomes also easier since it is not necessary to weight each blade before mounting and calculate its
30 position on the blower hub diameter in relation of the other blades having a different varying weight. In order to further decrease the weight variation, the blades are weighed after casting and sorted in weight classes. Thereafter the blades are ground by a diamond grinder
35 according to weighing results, the heaviest blades being worked on the most and the lightest the least, naturally. The finished blades may further be sorted in weight

classes in order to aid the mounting of the blades. If the weight class of the blades is marked at the factory, it is not any more necessary to weigh the blades when mounting, which speeds up the mounting greatly.

5

In the following the invention is described in greater detail by making reference to the appended drawings in which

10 Figure 1 is a view of one embodiment of a blower blade according to the invention;

Figure 2 is a diagram of a mould for manufacturing of the blades according to the invention including a cast blade;
15 and

In the following the weight variation is a weight difference of the lightest and the heaviest blade of the same size and configuration. This variation may be 3% or
20 smaller of the calculated design weight or alternatively 3% of the mean weight of the blades of a same size and configuration. Preferably the weight variation is 2% at the highest. The variation is examined "as cast", that is after casting of the blades before machining of the
25 blades but after removing material left in pouring basin and casting passage ways.

Next, the manufacture by casting of a blade according to the invention for a flue gas fan is described as an
30 exemplifying embodiment. Only the features characterizing the invention are discussed in detail and a more thorough description of casting of this kind of blades is in the WO 96/38247.

35 According to the embodiment described below, the fan blade is made by casting from a reinforced particle filled aluminum alloy. That part of the blade section 2

on which the erosive particles impinge perpendicularly is protected by a steel plate leading edge part 1. In those cases where the angle of attack on the blade is invariably oblique ($0^\circ - 15^\circ$) or the amount of erosive particles is insignificant, no wear protecting steel part is required. The steel plate construction 1 is bonded to the leading edge of the blade by integral casting and is extended to reach into the blade mounting key 3 moulded to the blade stem and the distal end of the blade correspondingly. The mounting key is shown here diagrammatically only. Thus, the steel leading edge 1 is attached to the blade section during the casting operation by integral cast bonding techniques.

15 The reinforcing filler of the blade composite material comprises silicon carbide particles with a particle diameter of 9 - 20 μm typical. Also other reinforcing materials and filler particle sizes are feasible. Typically, the proportion of the filler material is from 5 to 20 vol.-% depending on the application and degree of erosiveness under the operating conditions. The matrix component of the composite material typically is a castable aluminium alloy such as AlSi9Mg0.6. Also other castable aluminium alloys can be used. A suitable composite material for the fan blades of the above-described peat-fired power plant is the aluminium-matrix-based composite comprised of AlSi9Mg0.6 with 10 vol.-% of SiC (9.3 μm particle size) as the filler.

30 The protective wear strip or plate of the blade is made from Avesta 2205 duplex steel, for example. Other grades of steel suitable for this purpose are widely available and the choice can be made according to the availability and conditions in the environment where the blade is used. The steel plate leading edge 1 is integrally cast so as to extend into the blade stem key 3 thus imparting

extra strength to the area where the blade section 2 joins with the blade stem key 3. The leading edge protrudes also from the distal end of the blade so that the leading edge extends over the whole length of the blade. A backplate of the leading edge extends over almost half of the width of the blade. These features guarantee that the blade does not shatter totally if hit by any large objects accidentally entering the fan. The front edge of the steel leading edge 1 is additionally provided with a fixing lug 4 at which the steel leading edge 1 is fixed in place during casting by means of a pin inserted through the lug 4. Other shapes of blades equipped with a steel leading edge 1 or pad must have an appropriately modified design of geometry. The length of the blades made by this method is typically 100 - 1400 mm.

The leading edge 1 consists of three pieces: a backplate 5, a leading part 6 and a filler wire 7. The leading part 6 forms the profile of the front edge of the blade and is formed accordingly. The leading part has an U-form cross section. The backplate 5 is attached on the convex side of the leading part 6 and extends almost at the bottom of the groove formed inside the leading part 6. In the bottom of the groove of the leading part is a filler wire 7 and the edge of the backplate 5 rests on the wire 7. The leading part 6, the edge of the backplate 5 and the filler wire 7 are joined together by a discontinuous welding 8. Of coarse, continuous welding may also be used but then heavy heat transfer may cause deformations more easily. The backplate 5 is joined with the leading part 6 also at the edge of the convex side of the leading part 6. The backplate is bent first towards the center of the leading edge 1 and then directly away therefrom. Thus the part of the backplate 5 protruding from the leading part extends in the middle of the blade section 2. The protruding part of the backplate 5 comprises holes 9 for

attachment to the blade section 2. The holes 9 are advantageously made by punching, but drilling or other working methods may be used. The part of the backplate 5 located inside the leading part 6 comprises a row of triangular tongues 10 pointing towards the blade section 2. These tongues 10 are formed by punching and bending from the material of the backplate 5. The tongues 10 also serve for attachment of the leading edge 1 to the blade section 2. The backplate 5 and the leading part 6 have a material thickness of 2 mm, for example and the diameter of the filler wire 7 is 4 mm. The dimensioning of the materials is of course dependent on the dimensions of the blade.

The filler wire 7 right under the front edge of the leading part 6 enabled successful repair welding of the leading edge 1 by guaranteeing that there is enough material for the welding material to attach to. The convex side of the blade wears more rapidly, whereby this side is reinforced by two overlapping metal layers. This enables repair welding of this area also. The backplate 5 extends over almost the half of the width and the whole length of the blade and reinforces thus the whole blade.

In figure 2 the cast blade is shown in its casting mould. The casting mould comprises conventional upper 15 and lower 11 parts wherein a cavity for the blade 2 is formed. Further, on the side of the leading edge 1 of the blade there is a space for a steel leading edge 1 and a space for an electric resistor 13 which can be connected to a electric power source through leads 14

The casting proceeds as follows. The steel leading edge 1 is placed in its place in the lower part 11 of the mould and attached firmly on the mould trough a pin pushed through a hole 12 on the fixing lug 4 and pins pushed through holes on the end of the steel leading edge 1. The

electric resistor 13 is placed into the space provided therefor and the ends of the leads 14 are placed outside the mould. After these measures glue is spread on the lower part 11 of the mould and the mould is closed by placing the upper part 15 on the lower part 11. Now the cast steel leading edge 1 and the electric resistor 13 are kept tightly between the halves 11, 15 of the mould and electric current can be connected to the electric resistor 13 for heating the steel leading edge 1 and the mould for casting.

The heating of the steel leading edge is essential for successful casting for two reasons. First, it evaporates all moisture from the leading edge 1 and from the mould material, which might cause pores in the cast metal. Secondly, the heating prevents the cast metal to solidify too early whereby the metal flows freely into the inner volume of the leading edge 1 and the cast metal fills this volume thoroughly. Third, the heating removes free gases from the mould. The temperature of the steel leading edge 1 should be about 70 - 200 °C, advantageously 130 °C, at the beginning of the filling of the mould depending on the cast material and dimensions of the blade and leading edge. However, other temperatures may be useful in some occasion. The heating of the cast steel leading edge may be terminated before beginning the filling of the mould but it must be taken care that the leading edge 1 is at desired elevated temperature when the casting starts. The filling of the mould is performed in usual manner preferably using an automated tilting device that keeps the filling speed of the mould in optimum. The heating can be continued during the filling of the mould and the solidifying of the cast composite metal.

The power of the 170 W and eight moulds may be connected to a power source simultaneously. Heating period is 5

hours during which the temperature of the leading edge and the mould reaches 130 °C. This temperature ensures removal of free gases from the mould, which then ensures a product free of pores. By this method the weight
5 variation of the blades can be kept within 2% advantageously.

By using a steel plate leading edge 1 and preheating of the leading edge when it is within the mould in order to
10 keep it and the mould in elevated temperature at least until the filling of the mould begins, blades having a very low porosity and therefore small weight variation can be manufactured. By this method, the weight variation of the blades can be kept as small as 3% of the
15 calculated or medium weight and in some conditions even as small as 2%. Such a small weight variation removes the need of the balancing of the blowers or makes the balancing very easy when the blades are chanced.

20 After the blades have been cast and removed from the moulds, feeder heads and barbs are removed and the castings weighed. Then the castings are sorted into groups and ground by a diamond grinder into desired weight. The grinding also finishes the surface of the
25 blades. Finished blades are then sorted into at least three weight categories in order to aid balancing of a fan during installation.

Besides those described above, the present invention may
30 have alternative embodiments.

The steel leading edge can be heated by induction or connecting electric current directly on the cast steel leading edge. However these methods require more
35 sophisticated electric power sources to control the temperature of the steel leading edge. The important feature of the electrical heating is that it makes it

possible to heat the leading edge while it is within the mould thus preventing the cooling of the part before casting, which is evident if the part is heated in oven or by a blow torch before closing the mould.

5

Obviously, the shape of the blade is made to fit the operating environment and fan type using the same design rules as for any other blade, with the exception that the improved strength imparted by the novel material permits the use of smaller material thicknesses where desirable. The leading edge part can be surfaced for higher wear resistance by hard-chromium plating, for instance. Suitable steel grades for use in the leading edge part are, e.g., ferritic, austenitic and duplex steels. In principle, only the wear-subjected section of the blade need to be made from a composite material filled with reinforcing particles, whereby the blade stem, for instance, can be made from an alloy of aluminium or steel if so desired, because the blade stem jointed to the blade wheel hub has a substantially smaller tangential speed than the blade section thus undergoing less wear.

The castable material is advantageously selected from the group of composites commercially available from known manufacturers. Aluminium-matrix based composites are made at least by Duralcan, USA, and Hydro Aluminium, Norway. In the casting method itself, the appropriate design of the melt passageway is particularly crucial as was noted previously. The melt passageway shall be formed so that any possible bends caused by the pattern in the melt passageway are streamlined. For this purpose, the use of a manifold-type passageway may be necessary, whereby the number of parallel paths should, however, preferably be minimized.

35

The fan blades according to the invention are used in industrial fans operating under heavily erosive condi-

tions either at ambient temperature or in atmospheres of elevated temperatures. Flue gas fans of peat- or coal-fired power plants represent a typical application. The flue gases exit the power plant boiler at a temperature of 120°C to 150°C with a high content of flyash, whose particulate matter is both erosive and corrosive. Here, the fan blades according to the invention are most suitable for use in fans operated under a wide range of demanding conditions. While these fans are desiredly characterized by light weight, high wear resistance, tolerance to elevated temperatures and a certain degree of corrosion resistance, also other types of applications can be contemplated for the present invention.

Claims:

1. A fan blade for use under erosive conditions, the blade comprising a blade section (2) made by casting from a metal-matrix composite material containing reinforcing particles, a steel leading edge (1) bonded to the blade section by integral casting and fixing elements (3) at one end of the blade section for attaching the blade to a blade wheel hub of a fan, characterized in that the leading edge (1) comprises a leading part (6) having a cross section in form of U, the legs of the U-shape forming a convex part and a concave part of the edge of the blade, a filler wire (7) in the bottom of the leading part (6) and a backplate (5) attached under the convex leg of the leading edge (6) and extending over the whole length of the blade and towards the blade section (2).
2. A blade as defined in claim 1, characterized in that the parts of the leading part (1) are welded together.
3. A blade as defined in claim 1 or 2, characterized in that the metal-matrix composite material of the blade is comprised of aluminum, alloying components and a reinforcing filler selected from the group of silicon carbide, aluminum oxide and other ceramic particles.
4. A blade as defined in claim 1 or 2, characterized in that the weight variation of the blades of same size and construction is 3%, advantageously 2% and most advantageously 1% at highest
5. A blade as defined in claim 2, characterized in that the part of the backplate (5) located inside the leading part (6) comprises a row of triangular

tongues (10) pointing towards the blade section (2).

6. A method for producing a fan blade, comprising,

- 5 - placing a steel leading edge (1) within a mould
 (11, 15), and
- filling the mould (11, 15) with a metal matrix
 composite material containing reinforcing particles,
10 in order to form the blade (1, 2, 3) and to attach
 the leading edge (1) to the blade,
- c h a r a c t e r i z e d by heating the leading edge
 (1) electrically within said mould (11, 15) at least
15 before filling said mould (11, 15) with said metal matrix
 composite material simultaneously heating the mould (11,
 15.
- 20 7. A method according to the claim 6, c h a r a c t e r -
 i z e d in that the leading edge (1) is heated to a
 temperature of 70 - 200 °C, advantageously 130 °C before
 beginning of the filling of the mould.
- 25 8. A method according to the claim 6 or 7, c h a r a c -
 t e r i z e d in that the leading edge (1) is heated by
 an electric resistor (13) placed within the mould (11,
 15).
- 30 9. A method according to the claim 6 or 7, c h a r a c -
 t e r i z e d in that the leading edge (1) is heated
 through electric induction.
- 35 10. A method according to the claim 6 or 7, c h a r a c -
 t e r i z e d in that the wear pad is heated by
 connecting electric current directly to the leading edge

(1).

11. A method according to the claim 6, c h a r a c -
t e r i z e d by heating the leading edge (1) for at
5 least 5 hours.

1/2

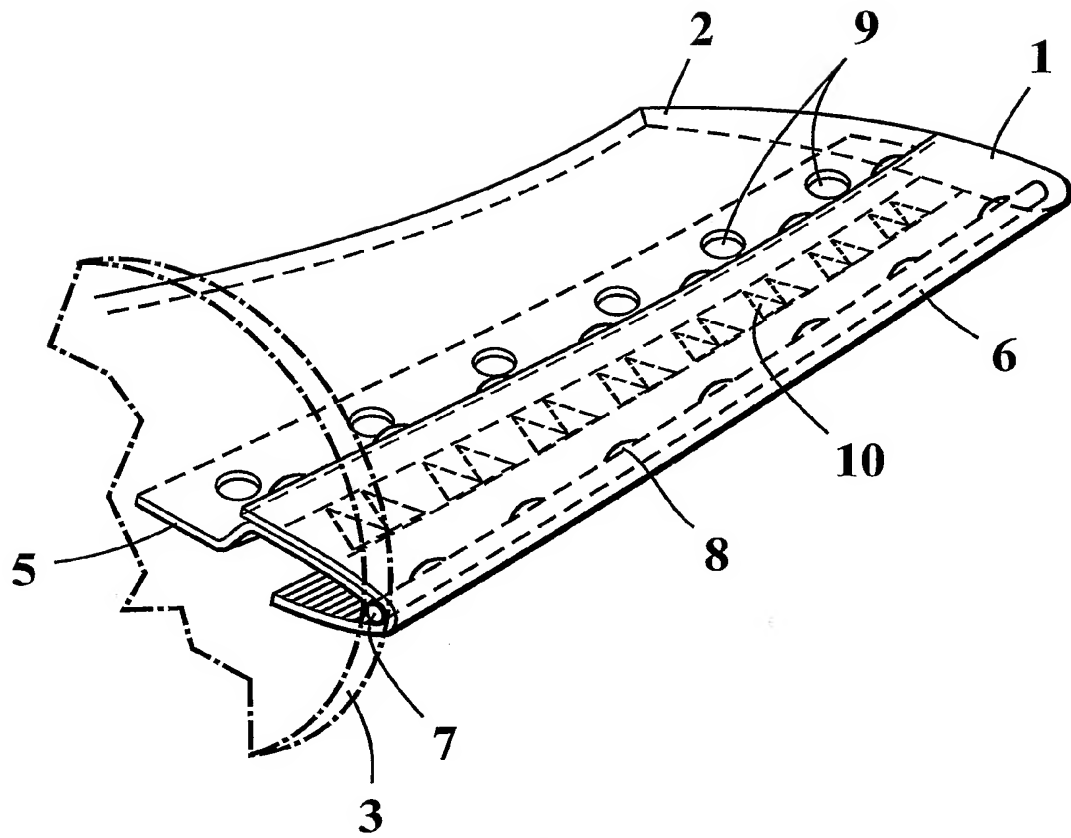


Fig. 1

2/2

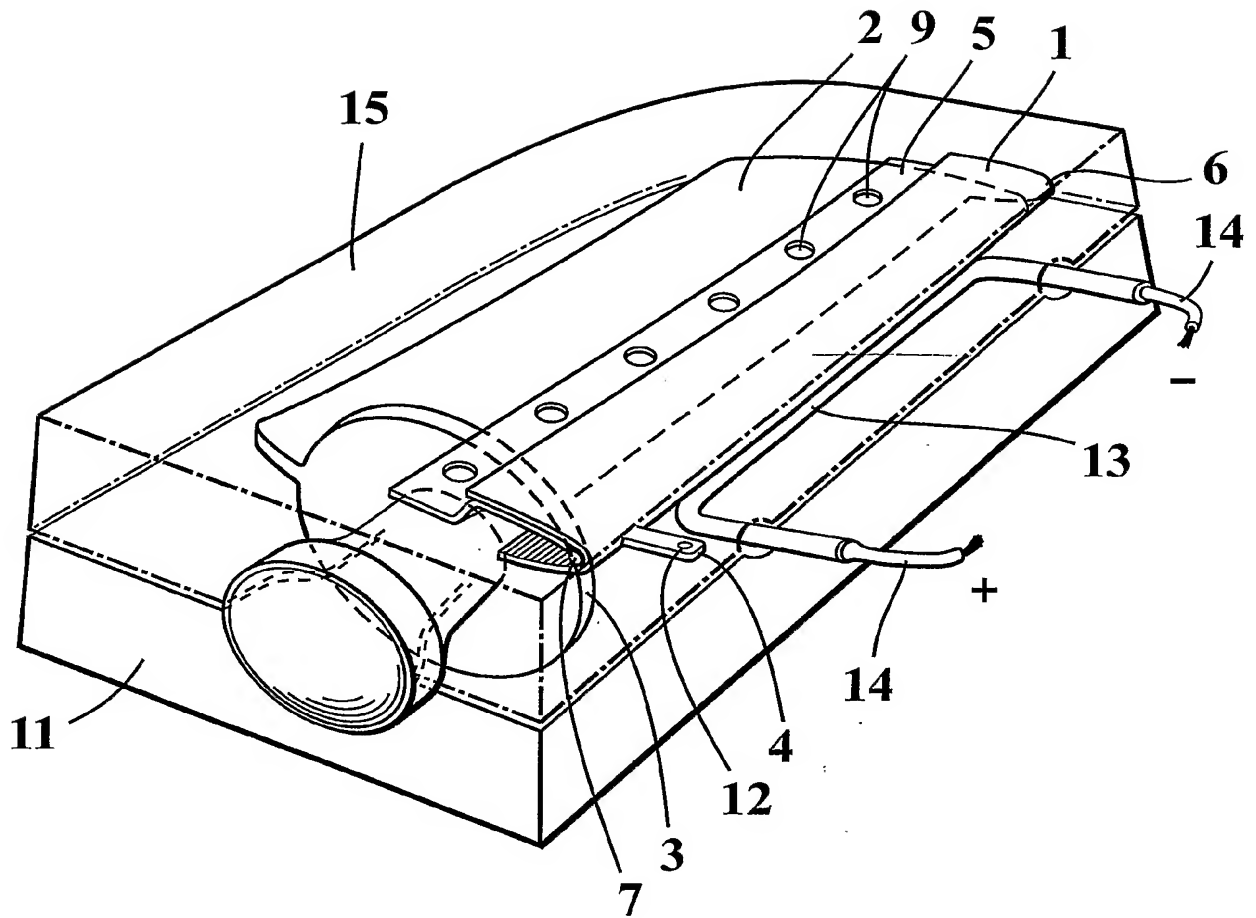


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 01/01111

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B22D 19/00, B22D 19/14 // F04D 29/26
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B22D, F04D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| A | WO 9638247 A1 (IMATRAN VOIMA OY), 5 December 1996 (05.12.96), abstract, claims, figures -- | 1-11 |
| A | US 4241110 A (MASATO UEDA ET AL), 23 December 1980 (23.12.80), abstract -- ----- | 1-11 |

☐

Further documents are listed in the continuation of Box C.

☒

See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

2 July 2002

Date of mailing of the international search report

10 -07- 2002

Name and mailing address of the ISA/

Swedish Patent Office

Box 5055, S-102 42 STOCKHOLM

Facsimile No. +46 8 666 02 86

Authorized officer

Ulf Nyström/MP

Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

10/06/02

International application No.
PCT/FI 01/01111

| Patent document cited in search report | | | Publication date | Patent family member(s) | | Publication date |
|---|---------|----|---------------------|----------------------------|------------------------|----------------------|
| WO | 9638247 | A1 | 05/12/96 | AU FI | 5822596 A 952698 D | 18/12/96 00/00/00 |
| US | 4241110 | A | 23/12/80 | ES JP | 482655 A 55014960 A | 16/02/80 01/02/80 |